Valve Inspection and Testing

API STANDARD 598
EIGHTH EDITION, MAY 2004

American
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Downstream Segment

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NOTES TO PURCHASER

1. If required, the following will be specified in the purchase order:

   a. Inspections by the purchaser at the valve manufacturer's plant (see 2.1).
   b. Inspections by the purchaser outside the valve manufacturer's plant (see 2.2).
   c. Address for inspection notices (see 2.3).
   d. Any supplementary examination required (see 2.6).
   e. Type of backseat test (see 3.2.2).
   f. Low-pressure closure test (see 3.3.3, 3.3.4 and 4.4.2).
   g. High-pressure closure test (see 3.4 and 4.5).
   h. High-pressure pneumatic shell test (see 3.5).
   i. Test fluid temperature for low temperature valves (see 3.6.1).
   j. Use of a wetting agent in the test water (see 3.6.4).
   k. Certificate of compliance (see 5.1).

2. If this standard is used for valves not covered by this standard, the purchaser will specify the extent to which the standard is to be applied.

Valve Inspection and Testing

1 General

1.1 SCOPE

1.1.1 This standard covers inspection, examination, supplementary examinations, and pressure test requirements for resilient-seated, nonmetallic-seated (e.g., ceramic), and metal-to-metal-seated valves of the gate, globe, plug, ball, check, and butterfly types. Resilient seats are considered to be:

a. Soft seats, both solid and semi-solid grease type (e.g., lubricated plug).
b. Combination soft and metal seats.
c. Any other type valve designed to meet resilient seat leakage rates as specified in Table 5.

API Std 598 supplements the API standards that reference it, but it may also be applied to other types of valves by agreement between the purchaser and the valve manufacturer.

1.1.2 The inspection requirements pertain to examinations and testing by the manufacturer and any supplementary examinations that the purchaser may require at the valve manufacturer's plant. The test requirements cover both required and optional pressure tests at the valve manufacturer's plant.

1.1.3 The following tests and examinations are specified in this standard:

a. Shell test.
b. Backseat test.
c. Low-pressure closure test.
d. High-pressure closure test.
e. Visual examination of castings.
f. High-pressure pneumatic shell test.

1.2 REFERENCED PUBLICATIONS

1.2.1 The most recent editions of the following standards, codes, and specifications are cited in this standard:

ASME[1]

B16.11	*Forged Steel Fittings, Socket-Welding and Threaded*
B16.34	*Valves—Flanged, Threaded, and Welding End*

MSS[2]

SP-45	*Bypass and Drain Connections*
SP-55	*Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components—Visual Method*
SP-91	*Guidelines for Manual Operation of Valves*

1.2.2 This standard supplements the following API valve standards:

API

Std 594	*Check Valves: Wafer, Wafer Lug and Double Flanged Type*
Std 599	*Metal Plug Valves—Flanged, Threaded and Welding End*
Std 602	*Compact Steel Gate Valves—Flanged, Threaded, Welding and Extended Body Ends*
Std 603	*Corrosion-Resistant, Bolted Bonnet Gate Valves—Flanged and Butt-Welding Ends*
Std 608	*Metal Ball Valves—Flanged, Threaded, and Butt-Welding Ends*
Std 609	*Butterfly Valves: Double Flanged, Lug- and Wafer-Type*

2 Inspection, Examination, and Supplementary Examination

2.1 INSPECTION AT THE VALVE MANUFACTURER'S PLANT

The purchaser will specify in the purchase order his intention to inspect valves and witness tests and examinations at the valve manufacturer's plant. The purchaser's inspector shall have free access to any part of the plant concerned with manufacture of the valves whenever work on the order is under way.

2.2 INSPECTION OUTSIDE THE VALVE MANUFACTURER'S PLANT

When the purchaser specifies that the inspection will include shell components manufactured at locations other than the valve manufacturer's plant, these components shall be subject to the purchaser's inspection at the location where they are manufactured.

2.3 INSPECTION NOTICE

When inspection by the purchaser is specified, the valve manufacturer shall notify the purchaser 5 working days prior to the required valve testing and any specified supplementary inspections or examinations, addressing the notice as stated in the purchase order. The valve manufacturer shall also give the purchaser 5 working days' notice of where and when shell components manufactured outside the valve manufacturer's plant may be inspected, if such inspection is required.

[1]ASME International, 3 Park Avenue, New York, New York 10016. www.asme.org
[2]Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, N.E., Vienna, Virginia 22180. www.mss-hq.com

Table 1-A—Pressure Tests

Valves: NPS ≤ 4 & ASME Class ≤ 1500
NPS > 4 & ASME Class ≤ 600

Test Description	Valve Type					
	Gate	Globe	Plug	Check	Floating Ball	Butterfly and Trunnion Mounted Ball
Shell	Required	Required	Required	Required	Required	Required
Backseat[a]	Required	Required	NA	NA	NA	NA
Low-pressure Closure	Required	Optional[c]	Required[b]	Optional[c]	Required	Required
High-pressure Closure[d]	Optional[c, f]	Required[e]	Optional[b, c, f]	Required	Optional[c, f]	Optional[c, f]

Notes: NA = Not applicable.
[a]The backseat test is required for all valves, except for bellows seal valves, that have the backseat feature.
[b]For lubricated plug valves, the high-pressure closure test is mandatory and the low-pressure closure test is optional.
[c]When the purchaser specifies an "optional" test, the test shall be performed in addition to the required tests.
[d]The high-pressure closure test of resilient-seated valves may degrade subsequent sealing performance in low-pressure service.
[e]For power-operated and manually operated gear actuated globe valves, including non-return type globe valves, the high-pressure closure test shall be performed at 110% of the design differential pressure used for sizing of the operator.
[f]A high-pressure closure test is required for all valves specified to be double block and bleed valves.

2.4 EXTENT OF INSPECTION

The extent of inspection may be specified in the purchase order and, unless otherwise indicated, will be limited to the following:

a. Inspection of the valve during assembly to ensure compliance with the specifications of the purchase order. Inspection may include the use of specified nondestructive methods.
b. Witnessing of the required and specified optional pressure tests and examinations.
c. Witnessing of any supplementary examinations (see 2.6).
d. Review of mill records and nondestructive examination records (including specified radiographs).

2.5 EXAMINATION

2.5.1 A visual examination shall be performed by the valve manufacturer of all castings of bodies, bonnets, covers, and closure elements to assure conformance with MSS SP-55.

2.5.2 The valve manufacturer shall examine each valve to assure compliance with this standard and the referenced purchase specification (e.g., API Std 599).

2.5.3 All examinations shall be performed in accordance with written procedures that comply with the applicable standards.

2.6 SUPPLEMENTARY EXAMINATION

Supplementary types of examination are required only if specified in the purchase order and only to the extent specified. Magnetic particle, radiographic, liquid penetrant, and ultrasonic examination of steel castings or forgings shall be in accordance with Part 8 of ASME B16.34 or with the purchaser's own procedures and acceptance criteria, if so specified. These examinations shall be made by the valve manufacturer subject to witnessing by the purchaser's inspector.

3 Pressure Tests

3.1 TEST LOCATION

Pressure tests shall be performed by the valve manufacturer at the valve manufacturer's plant.

3.2 TEST EQUIPMENT

The equipment used by the valve manufacturer to perform the required pressure tests shall not apply external forces that affect seat leakage. If an end-clamping fixture is used, the valve manufacturer shall be able to demonstrate that the test fixture does not affect the seat sealing capability of the valve being tested. End clamping is allowed for valves designed to function between mating flanges, such as wafer check and wafer butterfly valves.

3.3 TESTS REQUIRED

3.3.1 The pressure tests listed in Table 1-A or 1-B shall be performed on each valve in accordance with written procedures that comply with this standard.

3.3.2 At the manufacturer's option, the backseat test for valves that have the backseat feature may be either a high-pressure or a low-pressure test unless stated otherwise in the purchase order.

3.3.3 Valves NPS 4 and smaller having pressure ratings up to and including ASME Class 1500 and valves larger than NPS 4 having pressure ratings up to and including ASME Class 600 shall be tested in accordance with Table 1-A.

Table 1-B—Pressure Tests

Valves: NPS ≤ 4 & ASME Class > 1500
NPS > 4 & ASME Class > 600

Test Description	Valve Type					
	Gate	Globe	Plug	Check	Floating Ball	Butterfly and Trunnion Mounted Ball
Shell	Required	Required	Required	Required	Required	Required
Backseat[a]	Required	Required	NA	NA	NA	NA
Low-pressure Closure	Optional[b]	Optional[b]	Optional[b]	Optional[b]	Required	Optional[b]
High-pressure Closure[c]	Required	Required[d]	Required	Required	Optional[b, e]	Required

Notes: NA = Not applicable.
[a]The backseat test is required for all valves, except for bellows seal valves, that have the backseat feature.
[b]When an "optional" test is specified by the purchaser, the test shall be performed in addition to the required tests.
[c]The high-pressure closure test of resilient-seated valves may degrade subsequent sealing performance in low-pressure service.
[d]For power-operated and manually operated gear actuated globe valves, including non-return type globe valves, the high-pressure closure test shall be performed at 110% of the design differential pressure used for sizing of the operator.
[e]A high-pressure closure test is required for all valves specified to be double block and bleed valves.

The purchaser may elect to require an "optional" pressure test in Table 1-A.

3.3.4 Valves NPS 4 and smaller having pressure ratings greater than ASME Class 1500 and valves larger than NPS 4 having pressure ratings greater than ASME Class 600 shall be tested in accordance with Table 1-B.

The purchaser may elect to require an "optional" pressure test in Table 1-B.

3.4 HIGH-PRESSURE CLOSURE TEST

The high-pressure closure test is required for several valve types, as shown in Table 1-A and 1-B. For the valve types for which, according to Table 1-A and 1-B, the high-pressure closure test is optional, the valves are still required to be able to pass the test (as a test of the design of the valve closure structure). Results of tests confirming the capacity of the valve design to pass the high-pressure closure test shall be supplied when requested in the inquiry purchase requisition, or by the purchaser.

3.5 HIGH-PRESSURE PNEUMATIC SHELL TEST

When specified by the purchase order, a high-pressure pneumatic shell test shall be performed. This test shall be performed after the hydrostatic shell test, using appropriate safety precautions. The pneumatic shell test pressure shall be 110% of the maximum allowable pressure at 100°F (38°C) or as specified in the purchase order. Visible leakage is not allowed.

3.6 TEST FLUID

3.6.1 For shell, high-pressure backseat, and high-pressure closure tests, the test fluid shall be air, inert gas, kerosene, water, or a non-corrosive liquid with a viscosity not higher than that of water. Unless otherwise specified in the purchase requisition, the test fluid temperature shall be within the range 41°F (5°C) to 122°F (50°C).

3.6.2 For the low-pressure closure and low-pressure backseat tests, the test fluid shall be air or inert gas.

3.6.3 When air or gas is used for closure, shell, or backseat tests, the valve manufacturer shall be capable of demonstrating the adequacy of the method of leakage detection.

3.6.4 Water used for any test may contain water-soluble oil or rust inhibitor. When specified by the purchaser, a wetting agent shall be included in the water. For testing of austenitic stainless steel valves, water with chloride content not exceeding 100 parts per million shall be used. The valve manufacturer shall be able to document the chloride content.

3.7 TEST PRESSURES

3.7.1 The shell test pressure shall be as listed in Table 2.

3.7.2 Other test pressures shall be as listed in Table 3.

3.8 TEST DURATION

For each type of test, the required test pressure shall be maintained for at least the minimum time specified in Table 4.

3.9 TEST LEAKAGE

3.9.1 Shell, Stem Seals, and Backseat

3.9.1.1 For shell tests, visually detectable leakage through the pressure boundary walls and any fixed body joint is not permitted.

3.9.1.2 For backseat tests, visually detectable leakage is not permitted.

Table 2—Shell Test Pressure

Valve Type	Class	Shell Test Pressure (Minimum)	
		Pounds per Square Inch Gauge	Bar
Ductile Iron	150	400	26
	300	975	66
Cast Iron	125		
NPS 2-12		350	25
NPS 14-48		265	19
Cast Iron	250		
NPS 2-12		875	61
NPS 12-24		525	37
Steel			
Flanged	150 – 2500	[b]	
Buttweld	150 – 4500	[b]	
Threaded[a] and Socketweld	800	[c]	
	150 – 4500	[b]	

Notes:
[a] ASME B16.34 limits threaded-end valves to Class 2500 and lower.
[b] Per ASME B16.34.
[c] For Class 800 valves, the shell test pressure shall be $1^1/_2$ times the pressure rating at 100°F (38°C), rounded off to the next higher increment of 25 pounds per square in. gauge (or 1 bar) (see Table 2 of API Std 602).

Table 3—Other Test Pressures

Test	Test Pressure[d]	
	Pounds per Square Inch Gauge	Bar
Valves Except Butterfly and Check		
High-pressure closure and backseat [a]	[b]	
Low-pressure closure and backseat[a]	60 – 100	4 – 7
Butterfly Valve		
High-pressure closure	[c]	
Low-pressure closure	60 – 100	4 – 7
Check Valve		
High-pressure closure		
Class 125 (cast iron)		
NPS 2-12	200	14
NPS 14-48	150	11
Class 250 (cast iron)		
NPS 2-12	500	35
NPS 14-24	300	21
Class 150 (ductile iron)	250	17
Class 300 (ductile iron)	640	44
Carbon, alloy, stainless steel, and special alloys	[b]	
Low-pressure closure (See Tables 1-A and 1-B)	60 – 100	4 – 7

Notes:
[a] The backseat test is required for all valves that have this feature.
[b] 110% of maximum allowable pressure at 100°F (38°C) in accordance with the applicable purchase specification.
[c] 110% of design differential pressure at 100°F (38°C) in accordance with the applicable purchase specification.
[d] Single values shown are minimum test pressures. A range of values indicates both minimum and maximum test pressures.

Table 4—Duration of Required Test Pressure

Valve Size (NPS)	Minimum Test Duration (Seconds)[a]				
	Shell		Backseat	Closure	
	Check Valves (API Std 594)	Other Valves	All Valves with Backseat Feature	Check Valves (API Std 594)	Other Valves
≤ 2	60	15	15	60	15
2 1/2 – 6	60	60	60	60	60
8 – 12	60	120	60	60	120
≥ 14	120	300	60	120	120

Note: [a]The test duration is the period of inspection after the valve is fully prepared and is under full pressure.

Table 5—Maximum Allowable Leakage Rates for Closure Tests

Valve Size (NPS)	All Resilient Seated Valves[b]	All Metal-seated Valves Except Check		Metal-seated Check Valves	
		Liquid Test[a] (Drops Per Minute)	Gas Test (Bubbles Per Minute)	Liquid Test	Gas Test
≤ 2	0	0[b]	0[b]	[c]	[d]
2 1/2 – 6	0	12	24	[c]	[d]
8 – 12	0	20	40	[c]	[d]
≥ 14	0	e	f	[c]	[d]

Notes:
[a]For the liquid test, 1 milliliter is considered equivalent to 16 drops.
[b]There shall be no leakage for the minimum specified test duration (see Table 4). For liquid test, 0 drops means no visible leakage per minimum specified test duration. For gas test, 0 bubbles means less than 1 bubble per minimum specified test duration.
[c]The maximum permissible leakage rate shall be 0.18 cubic in. (3 cubic centimeters) per minute per in. of nominal pipe size.
[d]The maximum permissible leakage rate shall be 1.5 standard cubic ft (0.042 cubic meter) of gas per hour per in. of nominal pipe size.
[e]For valves greater than or equal to NPS 14, the maximum permissible leakage rate shall be 2 drops per minute per in. NPS.
[f]For valves greater than or equal to NPS 14, the maximum permissible leakage rate shall be 4 bubbles per minute per in. NPS.

3.9.1.3 For valves with adjustable stem seals, leakage through the stem seals during the shell test shall not be cause for rejection. However, the manufacturer shall demonstrate that the stem seals are capable of retaining pressure at least equal to the 100°F (38°C) valve rating without visible leakage.

3.9.1.4 For valves with non-adjustable stem seals (o-rings, fixed single rings, and the like), visually detectable leakage during the shell test is not permitted.

3.9.1.5 Where no visual detectable leakage is permitted, the following definitions apply:

a. If the test fluid is a liquid, there shall be no visible evidence of drops or wetting of the external surfaces of the test valve.
b. If the test fluid is air or inert gas, no leakage will be revealed by the established detection method.

3.9.2 For both the low-pressure closure test and the high-pressure closure test, visual evidence of leakage through the disk, behind the seat rings, or past the shaft seals (of valves that have this feature) is not permitted and structural damage is not permitted. (Plastic [permanent] deformation of resilient seats and seals is not considered structural damage.) The allowable rate for leakage of test fluid at the seat-sealing surface interface, for the duration of the tests, is listed in Table 5.

3.9.3 The allowable leakage rate for closure tests of valves with nonmetallic (e.g., ceramic) seat materials shall be equal to that specified in Table 5 for a metal-seated valve of equivalent size and type.

4 Pressure Test Procedures

4.1 GENERAL

4.1.1 Valves designed to permit emergency or supplemental introduction of an injectable sealant to the seat area shall be tested with the injection system empty and not in use, except for lubricated plug valves.

4.1.2 When a liquid is used as the test fluid, the valve shall be essentially free from trapped air during the test.

4.1.3 Required protective coatings, such as paint, which may mask surface defects, shall not be applied to any surface before inspection or pressure testing. (Phosphatizing and similar chemical conversion processes used to protect valve surfaces are acceptable even if applied before the tests, provided that they will not seal off porosity.)

4.1.4 When closure testing valves, the valve manufacturer's test procedure shall ensure that excessive force is not used to close the valve. The applied force may be determined from the appropriate figures in MSS SP-91, but in any case shall not exceed the values published by the valve manufacturer.

4.1.5 The valve shall be visually examined for leakage after it has been fully prepared and is under full test pressure.

4.2 BACKSEAT TEST

4.2.1 The backseat test is required for all valves, except for bellows seal valves, that have the backseat feature and shall be performed by applying pressure inside the assembled valve with the valve ends closed, the valve fully open, and the packing gland loose or packing not installed. If the backseat test is performed after the shell test, the packing shall be installed and/or packing glands re-tightened after the backseat test. The successful completion of the backseat test shall not be construed as a recommendation by the valve manufacturer that, while the valve is pressurized, the valve stuffing box may be repacked or the packing may be replaced.

4.2.2 For valves 4 in. NPS and smaller, the backseat test may be combined with the shell test when volumetric devices are used to monitor leakage from the shell and backseat. When tested by this method, the packing shall be loose. The manufacturer shall be responsible for demonstrating that the packing will not leak at the valve's rated pressure at 100°F (38°C).

4.3 SHELL TEST

Except as provided in 4.2.2, the shell test shall be made by applying the pressure inside the assembled valve with the valve ends closed, the valve partially open, and any packing gland tight enough to maintain the test pressure, thereby, except for bellows seal valves, testing the stuffing box.

4.4 LOW-PRESSURE CLOSURE TEST

4.4.1 The low-pressure closure test shall be performed with the seat sealing surface interface clean and free from oil, grease, and sealant. If necessary to prevent galling, the sealing surfaces may be coated with a film of oil that is not heavier than kerosene. This requirement does not apply to a valve that uses a lubricant as its primary seal (e.g., lubricated plug valves).

4.4.2 Any leakage at the seat sealing surface interface, behind the seat ring, or through the disk on the open side of the valve shall be detected when bubbles are observed coming from the closure (disk, seat, and seat ring), which is either covered with water or coated with a soap or similar solution.

As an alternative, displacement measuring devices may be used, provided that the detectable leakage rate is equivalent to that given in Table 5, the valve manufacturer can demonstrate and validate that the procedure yields results equivalent to the requirements of this standard, and the device has been accepted by agreement between the purchaser and the manufacturer. Bubbler testing, when used for valves larger than NPS 2, shall only be acceptable when agreed to by the purchaser.

When volumetric devices (bubblers) are used to measure leakage, the test duration shall not begin until flow through the test tubing is established and stabilized. The device shall be calibrated to yield results equivalent to the units per minute listed in Table 5. Volumetric devices shall be calibrated with the same test fluid and at the same temperature as used for the production tests.

4.4.3 When closure testing gate, plug, and ball valves, the valve manufacturer shall use a method of testing seat leakage that fills and fully pressurizes the body cavity to the test pressure between the seats and the bonnet area, as applicable, with the test fluid. This will ensure that no seat leakage can escape detection because of gradual filling of these volumes during the test period.

For a valve (other than a double block-and-bleed valve or globe valve) designed to close against pressure from either direction, the pressure shall be applied successively to each side of the closed valve with the other side open to the atmosphere to check for leakage at the atmospheric side of the closure. For a globe valve, pressure shall be applied in one direction with the pressure applied under the disk.

For a valve designed to close against pressure from one direction only and so marked, the pressure shall be applied on the pressure side of the valve only. For a check valve, the pressure shall be applied on the downstream side.

For a double block-and-bleed valve, the pressure shall be applied successively to each side of the closure through the valve port. Leakage into the body cavity between the seats shall be checked through observation at a tapped opening between the seats. Valves shall be tested with the stem in the

vertical upright position. Leakage from the seats shall not exceed rates shown in Table 5.

A closure test is required only in one direction for butterfly valves furnished with encapsulation or resilient internal liners and designed for use with Class 125 or Class 150 flanges (API Std 609 Category A valves). For other resilient-seated butterfly valves (API Std 609 Category B valves), the closure test is required in both directions. For valves with a preferred flow direction, the closure test in the non-preferred direction shall be based on the reduced differential pressure rating in that direction.

4.4.4 Trapping test air or gas in the body cavity between the seats of a one-piece (solid or flexible) wedge gate valve and subsequently covering the seats with water or coating them with soap or a similar solution does not constitute an acceptable low-pressure closure test.

4.4.5 If a tapped connection in the body cavity is made to permit testing procedures described under double block-and-bleed valve in 4.4.3, the connection shall be in accordance with MSS SP-45 and shall be fitted before shipment with a solid pipe plug (in accordance with ANSI B16.11) whose material composition is equivalent to that of the valve shell.

4.5 HIGH-PRESSURE CLOSURE TEST

4.5.1 The procedure for the high-pressure closure test shall be the same as the procedure for the low-pressure closure test except that, in the case of a liquid test, leakage shall be detected when drops, not bubbles as described in 4.4 are observed.

5 Valve Certification and Retesting

5.1 CERTIFICATE OF COMPLIANCE

When specified by the purchaser, the valve manufacturer shall submit to the purchaser a certificate of compliance as required in the purchase order.

5.2 RE-TESTING

A completed valve does not require re-testing unless inspection by the purchaser is specified in the purchase order. This re-testing may be waived by the purchaser's inspector upon written certification by the manufacturer that the valve has been inspected, tested, and examined for conformance with the requirements of this standard. Painted valves need not have paint removed for re-testing. Stored valves shall be commercially cleaned before re-testing and before shipment.

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